This is SCIENCE FRIDAY. I'm Ira Flatow. Those of us of a certain age can remember exactly what we were doing on a Friday this hour 50 years ago when we heard the news. President Kennedy's assassination horrified and transfixed the nation. It was murder in plain sight, seemingly the easiest kind of crime to solve. But 50 years later the basic facts of the case are still debated.

Was there a second shooter on the grassy knoll? Could a single bullet really hit the president and Texas Governor Connally and remain intact? This month Gallup reported that 61 percent of Americans still believe JFK's murder was a conspiracy. Well, also this month a new PBS documentary asks whether modern technology could crack the cold case.

"Cold Case JFK" aired on PBS series "Nova." It features the father and son ballistics team of Luke and Michael Haag and in the film the Haags use old school shooting reconstruction, plus they use modern high tech gadgetry not available to the Warren Commission or others that followed to probe the grassy knoll and the single bullet theories, and what they found is quite revealing.

I want to introduce them. Luke Haag is a forensic scientist specializing in ballistics, also the former technical director of the Phoenix crime lab. He joins us from Phoenix, Arizona. Welcome to SCIENCE FRIDAY.

LUKE HAAG: Thank you, Ira, from a rainy Phoenix.

FLATOW: Well, yeah. That's good news, I think.

HAAG: It is.

FLATOW: Michael Haag is also a forensic scientist specializing in ballistics. He's a senior forensic scientist with the Albuquerque Police Department and he joins us from Albuquerque. Welcome to SCIENCE FRIDAY.

MICHAEL HAAG: Thank you.

FLATOW: Luke, as a ballistic expert, what kind of test did you carry out on the magic bullet to prove whether there could really be a magic bullet or not?

HAAG: Well, a number of them. This is an extremely unusual bullet. It was unknown to the forensic community then, still pretty much the case now. So Mike and I have tracked this bullet through a variety of soft tissue simulates with Doppler radar, looked at deflection issues, filmed it with high-speed video, some of which you saw in the "Nova" program, a lot of which still has yet to be shown.

So those are some examples of things that weren't available in the '60s. Frankly weren't available until more recently.

FLATOW: And in the program you actually shot the bullet through three feet of pine, right? It went through - and then it emerged intact.

HAAG: Well, actually, Mike made the shot.

FLATOW: Mike.

HAAG: I just went up and dug the bullet out.

(LAUGHTER)

FLATOW: Mike, is that correct?

HAAG: Yeah. I think it was over three feet of wood, and one of the important aspects learned from this was just that this is a very stable bullet that as long as it stays nose forward, it takes quite a bit to stop it. And even though wood is not a more modern simulate for tissue, it also goes to the fact that if you just put it through tissue, like the president's neck, it really doesn't lose as much speed.

It certainly doesn't become deformed like a lot of people would think or expect.

FLATOW: And you discovered that the bullet, when it came out, actually started to tumble.

HAAG: Well, that's true when it goes through a soft tissue simulate, meaning something that simulates muscle tissue in human beings, and there are a number of those. And no matter what Mike and I fired these bullets through, they stayed stable in the tissue simulate, just as they did in John F. Kennedy's upper back and neck. But as soon as the bullet emerged into the air, it starts yawing or tumbling like a badly thrown football.

And that is of great importance when we come to Connally's entry wound.

FLATOW: Explain that.

HAAG: Well, Connally's entry wound, when Dr. Shaw examined it and later testified, is not a nice round hole. It's the consequence of a destabilized bullet, a bullet that's going end over end. And when Robert Frazier, the senior FBI examiner, examined the clothing of Governor Connally, he also reported and testified that the bullet that produced that entry hole in the coat was destabilized.

So if you use some scientific thinking, something had to destabilize that bullet. And one good choice, of course, is President Kennedy.

FLATOW: And so your bullet theory matched the actual testing evidence and the actual - the body, of how it entered Governor Connally.

HAAG: Yes. It's easy to see, if one takes the time to learn about this evidence, that this bullet can easily go through two people. In fact, if you line them up and add them together, this bullet, from what Mike was just telling you about three feet of wood, would go through two people and start to enter a third one.

FLATOW: So there's no reason then to call it a magic bullet.

HAAG: It is not magic. It never was magic, and neither is it pristine.

FLATOW: When you say that, tell us what you mean, it wasn't pristine.

HAAG: If one looks at the Warren Commission exhibits, and they're downloadable, the base view, looking at the back end of the bullet, it's oval. It's out of round. This is the consequence of slamming into Governor Connally while in yaw. That squeezes the bullet just like you'd squeeze a toothpaste tube and some of the soft lead core will now be extruded, whereas before, when it was going straight, either through the wood, through gelatin, through ballistic soap, or through President Kennedy, when it emerges from those materials, it's still perfectly cylindrical.

But not when it now slams into the governor going sideways.

FLATOW: And what - what significance is that to the case, about it not being pristine?

HAAG: Well, that's the point. It's been incorrectly called pristine and repeatedly magic. That's entered the public vernacular in this country. But it is not, and there's a reason for that and I just explained it, hopefully.

HAAG: I think another aspect of that too, is people like to say that this bullet, the stretcher bullet, if you will, caused seven wounds. I keep hearing that number over and over again. And really, that's also a misnomer. That really changes the perception that people have of what occurred with this projectile. It's not even close to seven.

People used the number seven by talking about entrances and exits, and that's really not what the bullet is experiencing. It experienced one impact when it comes to the president, going through the neck area. It experienced one impact or set of impacts going through Connally's chest, one with the wrist, and if anything, a half with regard to his thigh.

So really, it's only about three impacts that this bullet sustained.

FLATOW: Michael, you started by looking at Oswald's rifle. Is it possible to get off three shots in the time Oswald had to do it? Do you have to be a good shooter?

HAAG: You know, as long as you look at the physical evidence and come to the conclusion that the president and Connally were hit by the same bullet, that gives you multiple seconds of time to make the shot between the next shot and the head shot. And in fact, with this mechanism, it's a bolt-action rifle, it's a very simple action, it is absolutely possible.

And we've shot this set of trajectories, if you will, numerous times, and it is doable. It is absolutely something that is realistically possible, to come on target, fire one shot that would be quote-unquote the magic bullet, if you will, extract, eject, rechamber a cartridge, come back on target, and fire again to make the head shot.

The first shot is nominally about 60 yards, 60 to 65 yards, and the second shot, the head shot, would nominally be about 90 yards. With a four power scope on top of this gun, these are not difficult shots.

FLATOW: But they said there were three shots fired. Could it be that there were only two shots fired?

HAAG: No, I think that it's very realistically possible that three shots were fired. It's just that there's no absolute recovered physical evidence that indicates where that first shot was. Now, witnesses are notoriously horrible when it comes to recording what actually happened in an event. But many witnesses indicate that as soon as the president's limousine turned from Houston onto Elm Street, when he's right below the sixth floor depository window, that's when they hear the first shot. And actually one of the things that is online now with PBS's website - with the Nova website, is some videography and high-speed filming that we did to document what happens when you put bullets of this type into asphalt at the correct angles as would've occurred from the sixth floor down into the asphalt in the street.

MIKE HAAG: And there's some very revealing, interesting results there. And even though there's no physical evidence to unfortunately examine, I think it's a very realistic possibility that that first shot is the miss and it occurred right as the president was below the 6th floor window.

FLATOW: Luke, what other new technologies did you use in your experiments?

HAAG: Again, we were only able to show some of the things on the Nova program, but Mike's become a world class expert in the use of 3D laser scanning. And we included that to look at some deflection issues. In other words, dealing with that missing bullet, if it struck the tree branches, if it struck a traffic light, a support pole, what would happen to the bullet? How much deflection would it undergo? Mike did that with the laser scanning system. The Doppler radar was added to that to get impact velocity and exit velocity.

So these two tools allowed us to look at a lot of other what ifs. And I'd like to add to Mike's thing, there were three fired cartridge cases. And the predominant witnesses right around the - the best ear witnesses right around the intersection of Elm and Houston are all in pretty good agreement that there were three shots, including the three employees that are immediately below the shooter there on the 5th floor.

FLATOW: Tell us about how this new system - what is the Doppler? How does the Doppler work with ballistics?

HAAG: Well, it's a specialized system, not too different than the concept of police radar. It tracks moving objects, but it's designed for bullets. So you'll see it in a couple of the clips in the

Nova program as it looks like a conical device. It's sending out a microwave beam. It's following the bullet in its flight and giving the velocity at every inch, if I wanted to print it out that way. It will show the impact velocity.

It'll then show the velocity of the projectile or projectile fragments coming out the other side of the target. If it's fragmented, it'll track them individually. And finally, I can tell you if the bullet is intact or destabilized and what - how often it's yawing as it continues on its way. None of this was readily available until very recently.

FLATOW: Michael, let's talk about the fatal head shot. What happened there?

HAAG: I think one of the things that causes people a lot of confusion is the difference in the effect of the two different shots to the president, the one that strikes basically just soft tissue and the one that strikes his head. And unfortunately in this country and around the world, the majority of what the common populace believes about firearms is obtained - or education is obtain from TV and other illegitimate sources that really aren't doing - this really isn't doing the population any favors.

So when we examine what was going on with this particular type of ammunition, when it struck soft tissue versus when it struck actually harder bone, like skull bone, and then proceeded into a softer medium like brain matter, there were some very revealing results. And some of this is documented in the "Nova" program as well, just that in the soft tissue these bullets are very stable, they're very hard. They punch right through almost like an ice pick.

But then if you go to an impact to the head where this projectile does strike harder bone, it begins to either yaw very quickly or you can fail the jacket, begin to expose the softer lead core, and it becomes much closer to a hollow-point-style bullet in that. It begins to fragment and come apart. When you have...

FLATOW: Okay. I'm going to stop - let me stop you right there because we have to take a break. I want to get through those details to explain in greater detail and not run out of time. We're going to take a break, come back and talk more with Luke and Michael Haag after this break. Stay with us. We'll be right back.

(SOUNDBITE OF MUSIC)

FLATOW: This is SCIENCE FRIDAY. I'm Ira Flatow. We're talking this hour about the JFK assassination and what new technologies could tell us about this 50-year-old crime. My guests are Luke Haag, forensic scientist specializing in ballistics. His son, Michael Haag, senior forensic scientist with the Albuquerque Police Department. Michael, you were talking about the head shot and the misconceptions that people have had all these years about it. Please go back and re-explain that, if you will.

HAAG: Well, I think I was just trying to make the point - and this occurs regularly to forensic scientists dealing with firearms when they go in to testify, is that our juries, our common public, is mis-educated by what they believe to be truths with regard to what happens when bullets strike

things. So really what we're dealing with in the assassination of President John F. Kennedy is that we've got the same bullet striking him in two different ways in two different mediums, if you will. The next shot is soft tissue, so it behaves one way.

When this bullet struck his head, it fragmented and behaved very, very differently. It created a much larger what's called temporary cavity or splash effect, if you will, which is the reason why the head shot looks so dramatically different and is so much more catastrophic. But what's even more important here is that we have the physical evidence to back that up.

If you look at the fragments that were recovered in the front of the limousine, they're demonstrating exactly what happened. They're showing that this bullet came apart and there are legitimate physical reasons why this occurred. It struck the skull bone.

HAAG: And I should add, Ira, that those fragments are parts of a 6.5 millimeter Carcano bullet that Bob Frasier at the FBI and others after him matched back to Oswald's rifle.

FLATOW: The bullet was matched to the rifle.

HAAG: The fragmented bullet.

FLATOW: Fragmented.

HAAG: Two major pieces. Now, there's about 90 grains of the 160 of it missing. But importantly two fragments that have rifling marks on them were matched back to the same rifle abandoned on the 6th floor and later traced to Lee Harvey Oswald.

FLATOW: How did you - Mike, how did you reconstruct the head shot?

HAAG: Well, we used different medium and material. Of course, there's not too many volunteers that are willing to sustain this kind of thing, so we used things like ordinance gelatin to simulate the brain tissue, the internal organ tissue. And then we used actually flat bone from animals in order to simulate the skull. And, indeed, we're able to reproduce this fragmentation aspect in live fire testing.

FLATOW: There was the most recent film - a special on the Reels channel - maybe you're familiar with that - that talked about that there had been a Secret Service agent behind the car that carried the president with an AR15 assault weapon. And that he accidentally shot it and hit the president in his head and that would explain all the fragmentary hollow-point fragments left there. You're not buying that.

HAAG: I've seen the program, if I can jump in, Mike.

FLATOW: Yes.

HAAG: Please.

HAAG: It's just another example of the conspiracy industry. This is an old story that's just been exhumed after Agent Hickey has passed away. But it's easily disproved. In about three slides, if we were in a television studio, I could disprove it. First of all, there are no evaporating bullets, so where are the fragments of a 223 bullet? There are none.

The entry hole, the proponent of this idea drills a hole in a skull. First of all, the hole in the back of Kennedy's skull is not circular. It's elongated. And it's nominally 6 by 15 millimeters. This proponent doesn't realize that full metal-jacketed bullets can produce a hole in skull bone that's slightly smaller than the bullet that produced them. So those are just two quick reasons why this is an absurdity.

FLATOW: Let's talk about the grassy knoll theory. Michael, how did you put that to the test?

HAAG: Well, one of the interesting things - one of the interesting technologies that we used in this examination is what's called 3D laser scanning. And I used an instrument in conjunction with a good friend named Tony Grisham, we used what's called a lika scan station, in order to move about Dealey Plaza and use very accurate laser range finding to create a true digital 3D representation of Dealey Plaza, not only outside but also inside the 6th floor.

And by blending this data together you create one big huge three dimensional realistic world that is accurate for each data point to about 5 millimeters. Again, this is a technology that would've been unheard of in 1963 and is actually still developing within the forensic and crime scene community now. It's something that really came on the scene in about 2006. So actually I'm sitting here with my laptop in front of me looking at a representation of Dealey Plaza.

So whether it's the grassy knoll theory or a theory that a bullet came from the Dal-Tex building or any other potential place that anybody can think of right now, I can simply go into this 3D data and begin to get distances and angles and then evaluate whether or not, number one, the trajectories are even possible to reach the president. If they are, what would be the intercept angles with the president?

So for example, with the grassy knoll, it's certainly possible. I think anyone who stands there could also see that. But I can look at the distances and then determine with whatever gun we'd like to choose how much speed the projectile would lose over that distance and where the bullet would go through the president. With regard to the grassy knoll, I think there are two aspects, one forensic and one not, that kind of rule this out.

Number one, there's not a big of physical evidence to indicate there's an entrance on the front right, regardless of all the stories that I've heard. And number two, the left side of the president's head is relatively intact compared to the right. So if a shot were to come from the grassy knoll, the wound ballistics do not fit. It doesn't make sense.

But from a non-forensic perspective, I kind of have to laugh at the grassy knoll just because as an individual standing there, and as a shooter, it seems like such a strange, ridiculous place to try and attempt to assassinate someone from, because your back is to the open. You're standing with your back to a parking lot with a picket fence in front of you. It's laughable, quite frankly.

FLATOW: Something that's very graphic in the Zapruder film is that the president, as he - as the head shot happens, his head goes backwards as if he's getting shot from the front. It arches backwards. How do you explain that?

HAAG: Oliver Stone's one of the ones who I just saw recently stand up and say we can all see that the president's obviously shot from the front because his head moves back. There's two explanations for this. One's given by the lifelong wound ballistician named Larry Sturdivan, who worked for the wound ballistics lab. It may be neurological response. I'm not prepared to affirm or refute that at all. There's a physical explanation called Newton's third law of motion. And Mike and I have demonstrated this a number of times.

A doctor - Professor Alvarez also demonstrated it. It's basically if a bullet goes into the back of Kennedy's head and propels a quantity of brain matter that we see in frame 313 out the front, it's basically a propulsive effect, a jet effect, action reaction. Not the consequence of a frontal strike. The momentum of a bullet stopping in a human being barely moves him at all. And if that were true, if Oliver Stone were right, then there'd be a bullet in there because there's no exit in the back or in the left side of Kennedy's head.

So it has kind of a commonsense appeal. But when you look at those two choices, a neuro-spasm or physics or a combination of both, it's explainable.

FLATOW: There's no way...

HAAG: I think it's important to note there too that I learned at a very young age from my dad that you go out and you actually shoot these things. You shoot that type of ammunition on materials that are similar, as close as possible, and learn from what you're actually observing. So I mean that's real true observable science. And we've been able to do that in this case as well. Whether it's a mixture of neurological result or physics, we've been able to show the physics part of it.

FLATOW: So from your analysis of the physics, from the evidence, from your own testing, you can confirm that it was a single - the single bullet is not a magic bullet and there was no shot fired from a grassy knoll.

HAAG: There's no physical evidence to indicate anything else. That's correct.

HAAG: Not in half a century.

FLATOW: And it would be possible to get off those three shots - you did it yourself - using the same gun.

HAAG: Multiple times.

HAAG: It's the two that's important, Ira, because we have a missed shot for which there's no time sequence. But if it's - when the car turns the corner, there's plenty of time to do all three of them.

FLATOW: This is quite interesting stuff. If this crime happened today and we were able to investigate it with the technology we have now, do you think there would be conspiracy theories anymore?

HAAG: I think there will always be because there's something in our psyche that likes a mystery, that likes to think there's got to be more to it than just some loner, loser, ne'er-do-well Marxist or whatever the person's philosophy might be, could kill the leader of a country. So there's no stopping it, but my urging would be for those who have a scientific mind to find out what the physical evidence is, then to understand that physical evidence; there's where the public's been let down. No one has really explained what the physical evidence is in this case and what it means.

It probably won't change the minds of a lot of individuals, but the physical evidence and the findings will be lasting long after I'm gone and even after Mike's gone.

FLATOW: All right, gentlemen, thank you very much for taking time to be with us today.

HAAG: You're welcome.

HAAG: Thanks.

FLATOW: Luke Haag is a forensic scientist specializing in ballistics. He's a former technical director of the Phoenix Crime Lab. Michael Haag, also a forensic scientist specializing in ballistics. He's senior forensic scientist with the Albuquerque police department.